MODESTORE

WP 6: Field test: long term storage in combination with solar collectors (Austria)

Deliverable D9: Installed system equipped with monitoring devices in Austria

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Introduction

The 2nd generation system, which was developed in work package 4 has been installed in the laboratory facilities of AEE INTEC in Gleisdorf, Austria. The system was operated under controlled conditions and realistic load profiles for a single family house in Austria were simulated.

Measured system

The system was fitted with sensors to measure temperatures, pressures and flow rates of the different cycles. Further was the water level in the evaporator/condenser area measured as well as the amount of remaining water in the water storage tank. Figure 1 shows the schematic of the tested system, including the sorption heat store and the separate water tank as well as the hydraulics of the test facility used for the systems tests with the installed measurement equipment.
A heat source and a heat sink were used to make different operating conditions possible. The flow rates through the two heat exchangers were controlled as necessary. The adsorption heat exchanger delivers heat to the silica gel in the sorption store when being energetically charged and the stored heat energy is later removed and delivered to the simulated distribution network.

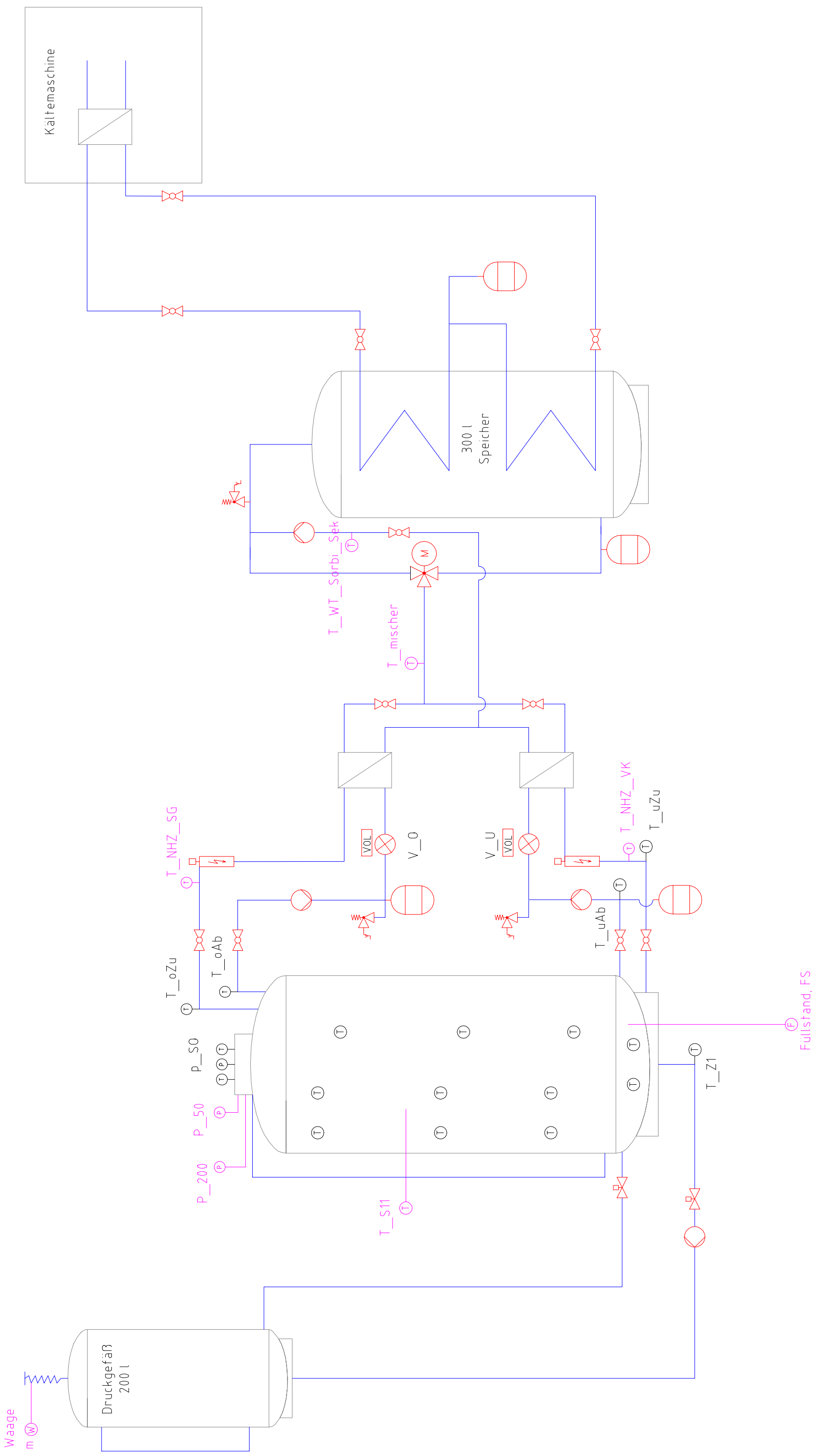

Figure 1: Schematic of the tested system of a sorption store under controlled conditions

The measured parameters are listed in table 1.

Table 1: Measured parameters for data logging with corresponding devices

Measurement		**Unit**	**Sensor type**
Temperature in silica gel (11 different positions, see figure 2 for details)	T_S	°C	PT 1000 4L 1/3 DIN B
Temperature in the vapour channel (on two different heights)	T_D	°C	PT 1000 4L 1/3 DIN B
Temperature at the evaporator/condenser (on two different heights)	T_W	°C	PT 1000 4L 1/3 DIN B
Temperature on the water inlet pipe, clip-on sensor	T_Z1	°C	PT 1000 4L 1/3 DIN B
Pressure sensor 1	p_50	mbar	Endress + Hauser, CERABAR-M PMC41 0-50 mbar
Pressure sensor 2	p_200	mbar	Piezo Steel SIN 01PS1017 0-1000 mbar
Water level	FS	Litre	Kobold NMT-1201R50
Weight water tank	m	kg	Thedea HUNTLEIGH Load Cell Type 615
Temperature inlet, adsorber heat exchanger	T_oZu	°C	PT 100 4L 1/10 DIN B
Temperature outlet, adsorber heat exchanger	T_oAb	°C	PT 100 4L 1/10 DIN B
Volume flow, adsorber heat exchanger	V_O	Litre	Viterra 1,5 m³ Type 414, HY 28099168
Temperature inlet, evaporator/condenser heat exchanger	T_uZu	°C	PT 100 4L 1/10 DIN B
Temperature outlet, evaporator/condenser heat exchanger	T_uAb	°C	PT 100 4L 1/10 DIN B
Volume flow, evaporator/condenser heat exchanger	V_U	Litre	Viterra 1,5 m³ Type 414, HY 28257978
Temperature surroundings	T_u	°C	PT 1000 2L 1/3DIN B
4 Thermocouples on adsorber heat exchanger (see figure 3 for details)	ΔRO etc.	ΔT	thermocouples type T

The temperatures in the sorption store were measured at 11 different positions, shown in detail in figure 2. The adsorption heat exchanger is presented in a cut through section, showing the sensors on and between the elements of the heat exchanger and the distances. The arrow pointing away from the scheme represents the position of the sensors, which are mounted on a grid level behind and above the other sensors.

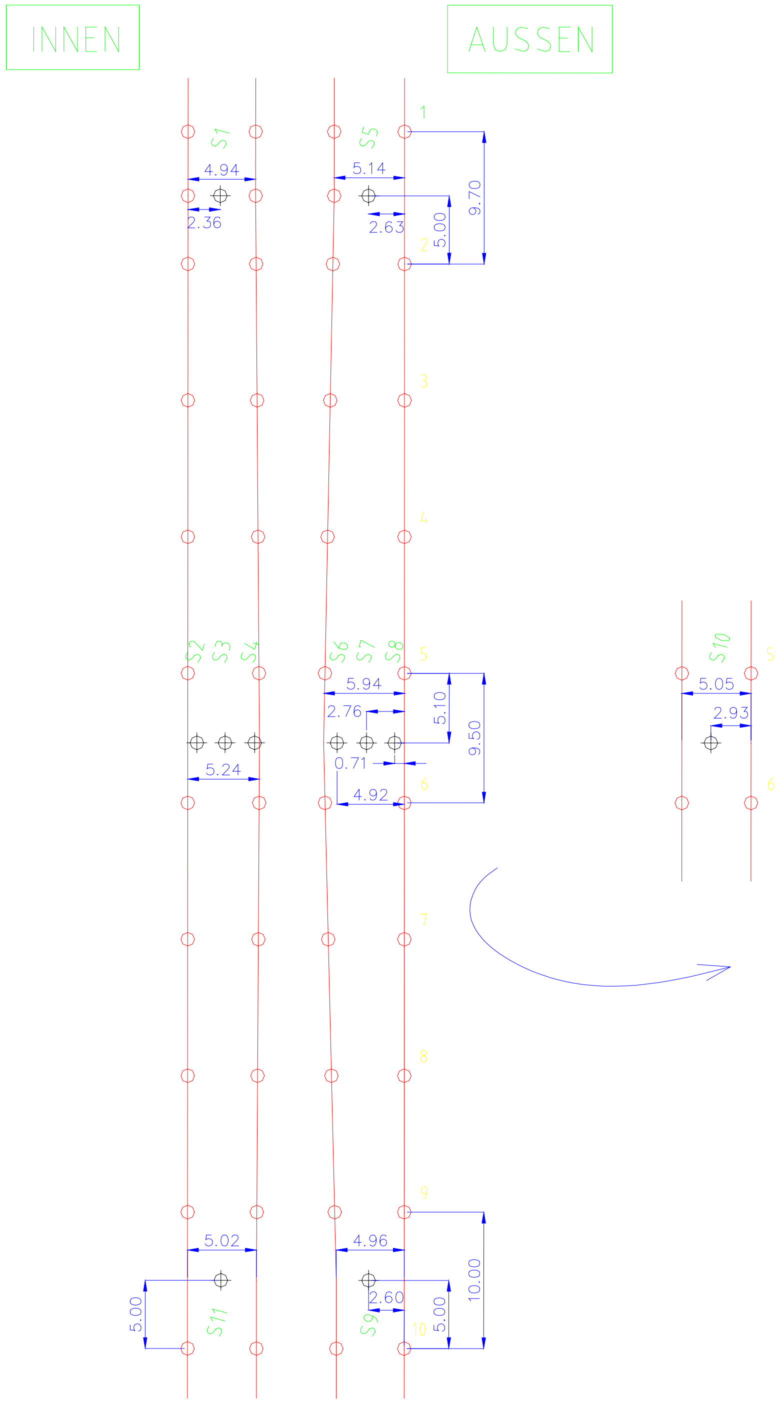

Figure 2: Sensor positions on the adsorber heat exchanger in the sorption store

Measurements of the temperature distribution within the silica gel packing allow to get information on the heat transfer from the heat exchanger to the silica gel and vice versa as well as within the silica gel. In addition, it will be possible to know the temperature distribution at different positions within the store.

In addition, the steam temperature in the vertical slot, which runs through the store tank in the central opening of the heat exchanger, is measured at two different heights. One is located 51 cm down from the upper edge of the silica gel packing, the other one 93 cm down. In the evaporator/condenser area of the tank, there are two sensors installed, one located just above the evaporator/condenser heat exchanger, the other one next to it.

The temperature sensor on the inlet pipe (T_Z1) to the store from the external water tank measures the outlet (and inlet) temperature of the condensed water. The water level in the evaporator/condenser area is measured so that the water balance could accurately be calculated, and thereby draw conclusions on the water content of the silica gel. Measuring the mass of the external water tank served the same purpose. The inlet and outlet temperatures to the adsorption and evaporator/condenser heat exchangers were measured to be able to establish energy balances, which was also the purpose of the flow rates and the surrounding temperature measurements.

Four thermocouples are soldered to the adsorption heat exchanger as is shown in figure 3. The grey and white bars represent the pipes in the heat exchanger and the grey areas are those where the pipes are soldered to the sheet metal. The temperatures are measured as temperature differences to a reference point on the heat exchanger. This means that no absolute temperatures were measured, but difference between the four measurement points were calculated. These temperature differences are shown in the figure as coloured arrows.

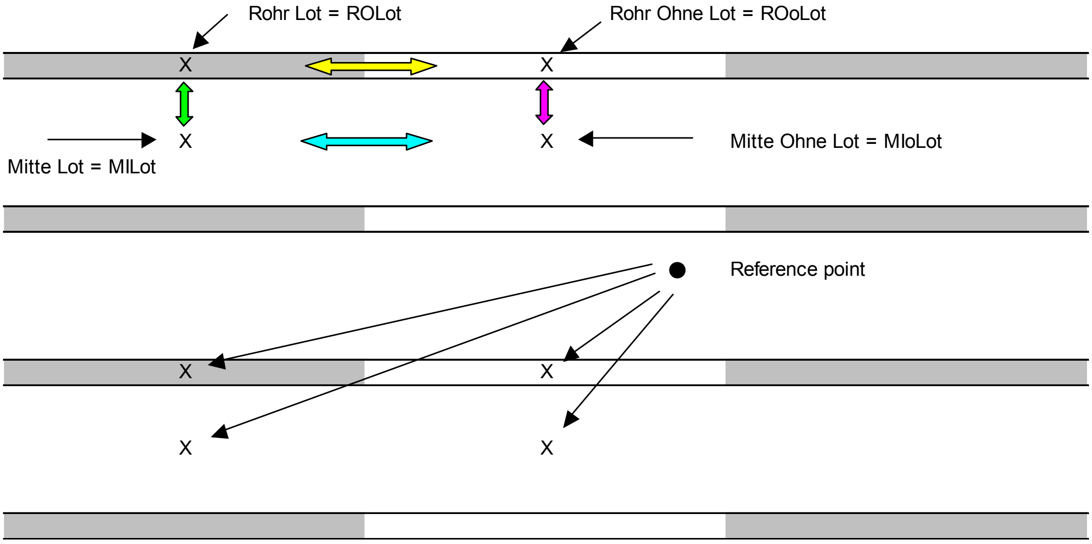

Figure 3: The thermocouples measurement points in relation to each other on the adsorber heat exchanger

Figure 4 shows the data logging equipment for the test facility which saves the data from the above described sensors with a 1-minute time interval.

Figure 4: Data logger system

Control system

Figure 5 shows the SPS control system, which was used to control the valves and the pumps, depending on the measured system temperatures and pressures and the water level in the sorption tank.

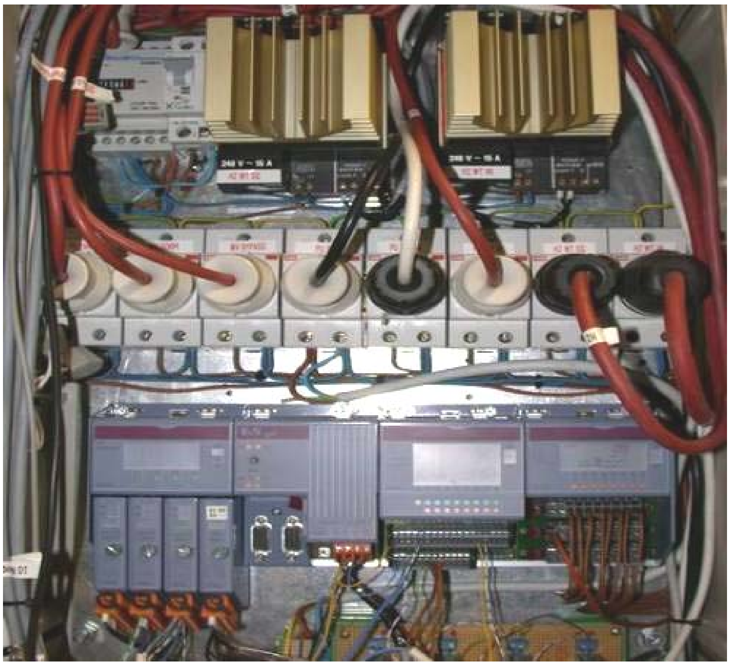

Figure 5: SPS control system

Table 2 shows the parameters measured by the SPS system. Five of them are also recorded by the data logging system. Four are only measured to control the heat sink and heat source during the tests (temperatures that control the electrical flow heaters directly behind the devices, mixing temperature for mixing valve, inlet temperature to buffer store on the secondary side).

Table 2: Measured control parameters with corresponding devices

Measurement		Unit	Sensor type
Weight water tank	m	kg	Thedea HUNTLEIGH Load Cell Type 615
Pressure sensor 1	p_SO	mbar	Endress + Hauser, CERABAR-M PMC41 0-50 mbar
Pressure sensor 2	p_Vb	mbar	Piezo Steel SIN 01PS1017 0-1000 mbar
Water level	FS	Litre	Kobold NMT-1201R50
Temperature behind electrical heating element in adsorber circuit	T_NHG_SG	°C	PT 1000 2L DIN B
Temperature behind electrical heating element in evaporator/condenser circuit	T_NHG_VK	°C	KTY 81-210
Temperature behind mixing valve	T_MISCHER	°C	KTY 81-210
Inlet temperature to buffer store	T_WT_Sorbi_sek	°C	KTY 81-210
Temperature in silica gel (Sensor #11)	T_S11	°C	PT 1000 4 L 1/3 DIN B

Desorption operation

As a desorption is in operation, the desorption heat exchanger delivers heat (in a real application heat energy from a solar thermal collector) to the silica gel and the water in the highly porous material is desorbed, the silica gel is dried and energetically charged. The heat is generated in the test setup by the electrical heating element in the circuit connected to the adsorber heat exchanger.

The condenser heat exchanger condenses the water vapour (under vacuum conditions) and the liquid water is pumped to the external water tank. The inlet temperature to the condenser is controlled by taking cold water from the buffer store, mixing it to the desired temperature and transferring it via the heat exchanger connected to the evaporator/condenser circuit. The buffer store serves as a heat sink as is cooled by a heat pump.

Adsorption operation

When in adsorption operation, the sorption store and the silica gel are energetically discharged. The water from the external water tank is led to the bottom of the sorption tank. The evaporator/condenser heat exchanger delivers enough heat (again under vacuum conditions), to evaporate the delivered water, which is then taken up (adsorbed) by the silica gel and its water content, x [kg water/kg silica gel], increases. The heat is delivered from the electrical heating element in the evaporator/condenser circuit. As the water is absorbed, the heat energy is discharged via the upper heat exchanger. Unlike in desorption mode, the buffer store and the mixing valve now control the simulated space heating return temperature.

Manually operated ball valves have to be switched to set which heat exchanger the heat sink operates on depending on the operation mode.